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ELECTRO-OPTICAL TRANSMISSION AND LIQUID WATER CONTENT  
OF FOGS AND CLOUDS(U) UNIVERSITY COLL GALWAY (IRELAND)  
S G JENNINGS SEP 83 DAJA77-81-C-0003

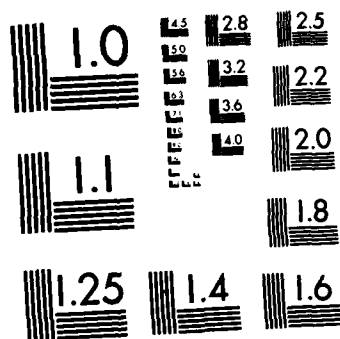
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ELECTRO-OPTICAL TRANSMISSION AND LIQUID WATER CONTENT OF FOGS AND CLOUDS

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ELECTRO-OPTICAL TRANSMISSION AND LIQUID WATER CONTENT OF FOGS AND CLOUDS

The prediction of atmospheric extinction from a measureable fog or cloud microphysical parameter such as liquid water content is of considerable practical interest. It is important that absolute methods for the measurement of liquid water content are carefully evaluated. This interim report describes experimental techniques used to measure absolutely liquid water content of laboratory cloud.

One of the first more reliable methods for the measurement of the liquid water content of fog was used by Houghton and Radford (1938). The amount of fog water was measured by passing a known amount of fog laden air through a series of finely spaced thin wire screens. An impaction method is also used here whereby the cloud droplets impact onto a series of flannel filters. This method was first used by C.W. Bruce (personal communication) and is referred to by Bruce et al. (1980). A schematic diagram of the liquid water impaction device is shown in Figure 1. The core of the liquid water content (LWC) device consists of an aluminium ring system which consists of a series (usually 4) circular sheets of flannel material resting on a fine gauge metal perforated screen or gauze. A threaded collar is used to firmly secure the filter material when the cloudy air is drawn through the device. An o-ring assembly is used to ensure that no extraneous air is drawn into the system. A compressor pump (P) together with a calibrated rotameter (R) was used to give the volume of cloudy air drawn through the filter assembly over a selected time period.

An electronic timer circuit in conjunction with a solenoid and a relay was used to actuate the aspiration pumps. It also served to remove a flap positioned directly over the intake tube to prevent cloudy air from entering the LWC device before sampling. The timer circuit was used to preselect the sampling period for the experimental measurements. Subsidiary comparative measurements were made of the air flow at the entrance and exit ports of the LWC device due to relatively small pressure drop in the system and appropriate corrections were made to the incoming airflow values as inferred from the rotameter R readings. Measurements using a range of different numbers of flannel filters indicated that 4 flannel filters were sufficient to capture all of the cloud water under typical operating conditions.

A second identical LWC device was placed close to the LWC impactor to serve as a reference. Cloudy air was not aspirated through the reference LWC device, rather the cloud droplets were allowed to fall onto the filter assembly over the same sampling period as the measuring system. It was found that the amount of cloud liquid water collected in the reference filter was significant and must be taken into account in order to take reliable and accurate liquid water content measurements. The filter ring assembly was preweighed on an Oertling balance (typical weight  $\sim 30$  g) and stored in a dessicator. It was usual to weigh the filter, using the Oertling balance, immediately after the cloud was drawn through the LWC device.

Another arrangement was also set up to measure liquid water content of the cloud directly. This incorporated a top loading Sartorius model 1212 MP balance. A schematic diagram of the system is shown in Fig.2. Cloud laden air is drawn through a funnel shaped impactor which is packed with flannel material, by means of a compressor pump. A rotameter, R, is also in the line to measure the total volume of cloud sampled. A housing surrounds the impactor which is mounted horizontally, in order to minimise cloud from entering the device under conditions of no suction. The housing has an opening of diameter equal to the impactor tube. Recordings of cloud water content could be made directly with the top balance system. The cloud water content per unit volume was obtained from the mass flow rate measurements of the device.

A comparison was made between the direct filtration methods using the vertical tube arrangement with its reference tube and the top loading balance arrangement with its horizontal filter assembly. Both systems were adjacent to one another in a  $1\text{ m}^3$  chamber lined with water absorbing black material which was pre-wetted to yield a water saturated environment for the cloud droplets. The cloud was produced by a commercially available "cool mist vapouriser" or humidifier whose output was controllable by a range of baffle settings. The results of the LWC comparison are given in Table 1.

It can be seen that in general agreement between the two filtration methods is good. Agreement is somewhat mitigated as the filter material in the top-balance assembly becomes more wetted, resulting in an apparent loss of collected cloud water. It is also clear that the use of a reference impaction assembly is imperative when using the direct filtration technique for the measurement of liquid water content.

#### REFERENCES

Houghton, H.G. and W.H. Radford, 1938: "On the measurement of drop size and liquid water content in fogs and clouds" Phys. Ocean. and MET. 6, 1-31.

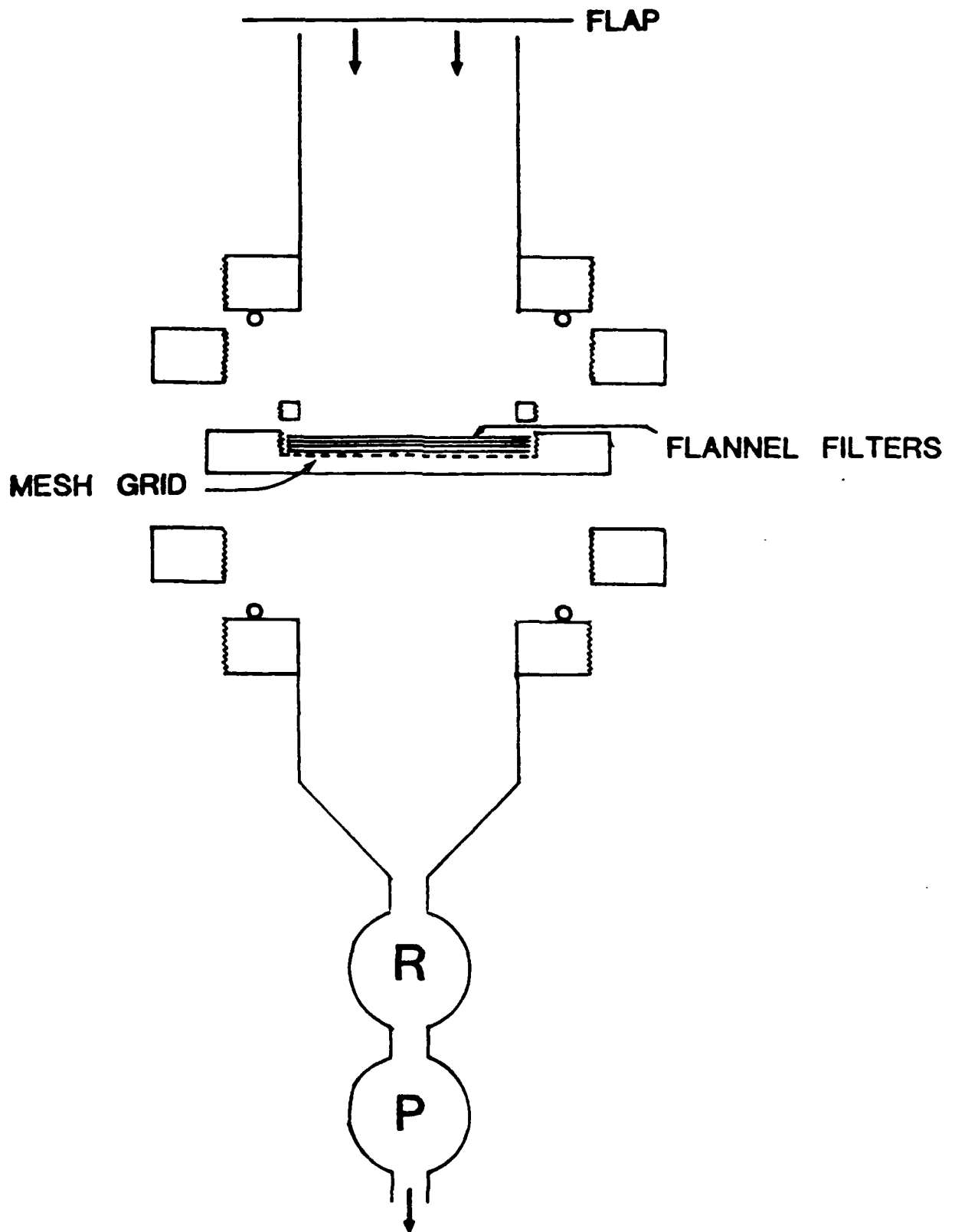
Bruce Dorothy, Charles W. Bruce, Young Paul Yee, Lynn Cahenzli and H. Burket, 1980: "Experimentally determined relationship between extinction coefficients and liquid water content", Applied Optics, 19, 3355-3360.

TABLE 1

Comparison of 2 filtration techniques for liquid water content measurement of cloud

Cloud Generator	Mass (g) using vertical filtration tube	Mass (g) using reference tube	Net mass of water (g)	Flow rate -1 l mm	Sampling time S	Mass of cloud using top-balance (g)	Diredt Filtration Mass	
							Top-balance mass	Top-balance mass
2 Humidifiers medium setting	0.063	0.016	0.047	8	117.7	0.039		1.17
" "	0.555	0.013	0.042	8	117.7	0.037		1.11
" "	0.055	0.016	0.039	8	117.4	0.040		0.98
2 Humidifiers high setting	0.102	0.016	0.086	5	174.8	0.074		1.16
" "	0.102	0.014	0.088	5	175.7	0.064		1.37
" "	0.100	0.013	0.087	5	175.7	0.064		1.36
Replaced top-balance filter and restarted cloud								
" "	0.092	0.013	0.079	10	98.4	0.082		0.96
" "	0.100	0.009	0.091	10	98.0	0.079		1.16
Replaced filter in top-balance assembly								
" "	0.103	0.019	0.084	10	98.2	0.080		1.05
" "	0.112	0.017	0.094	10	98.6	0.085		1.10
" "	0.107	0.016	0.091	10	98.5	0.077		1.19
Dry filter replaced in top-balance assembly								
" "	0.102	0.021	0.081	10	98.3	0.081		1.00
2 Humidifiers low setting	0.075	0.009	0.066	10	98.4	0.069		0.96

Fig. 1 LWC MEASUREMENT SYSTEM -DIRECT FILTRATION





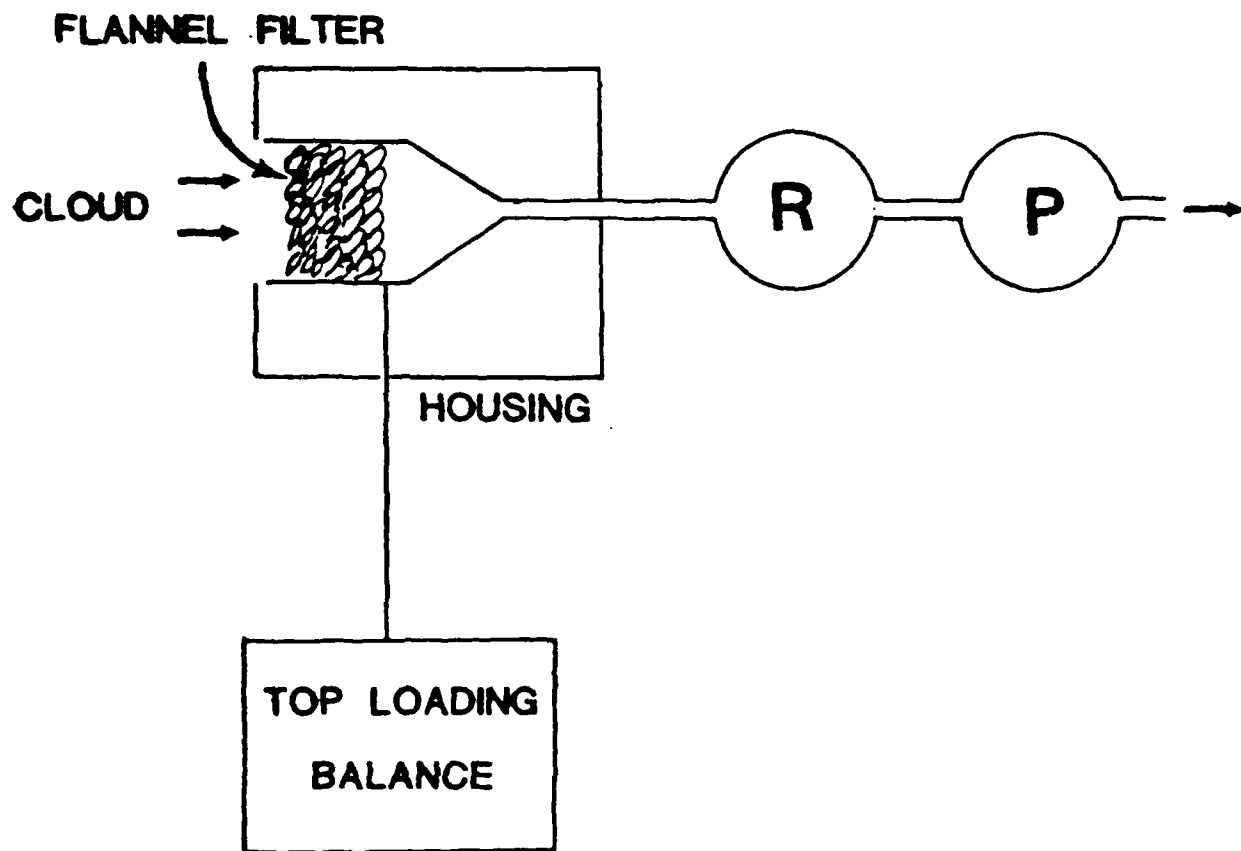


Fig. 2 LWC MEASUREMENT SYSTEM

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